Low Cost, Hands-on Science & Technology Experimentation & Demonstrations

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Nathan Chao
Bernard E. Mohr
Queensborough Community College
The City University of New York

Need for Remote Laboratory Capability

- Many CC students are older, have families, have part and full time jobs, some may travel great distances, and some may be enrolled part-time.
- Distance learning systems have mostly facilitated delivery of course content information and laboratory demonstrations.

Drawbacks of Three Laboratory Methods

Traditional Method

- Traditional laboratory instruments and facilities require costly startup, maintenance and setup costs.
- Requires students to perform mandated laboratory assignments in campus laboratories.

Drawbacks of Three Laboratory Methods

Remote Control

- Instruments connected to a host instrument-server.
- Effective when the laboratory instruments are too costly for institutions to install.
- A major deficiency of this approach is that each experiment must be performed online as the *experiment of the week*.
- To make all course experiments available is extremely costly.
- Remote approach also suffers because it deprives students of hands on with real components and wires.

Drawbacks of Three Laboratory Methods

Computer Simulations

- Compromises the promise of technology by replacing real instruments and measurements with simulations.
- This virtual method deprives students of experiencing and observing real physical phenomena in their course of study.

Development of Alternate Strategies*

1. **Interactive Internet Laboratory (IIL):**
   Computer controlled bench lab instruments w/ Web-based courseware and instrument controls in a custom WebLAB browser.

2. **Distance Hands-on Laboratory:**
   A unique local instrument box [e-LAB] fully integrated with WebLAB courseware and instrument controls in Microsoft Internet Explorer.

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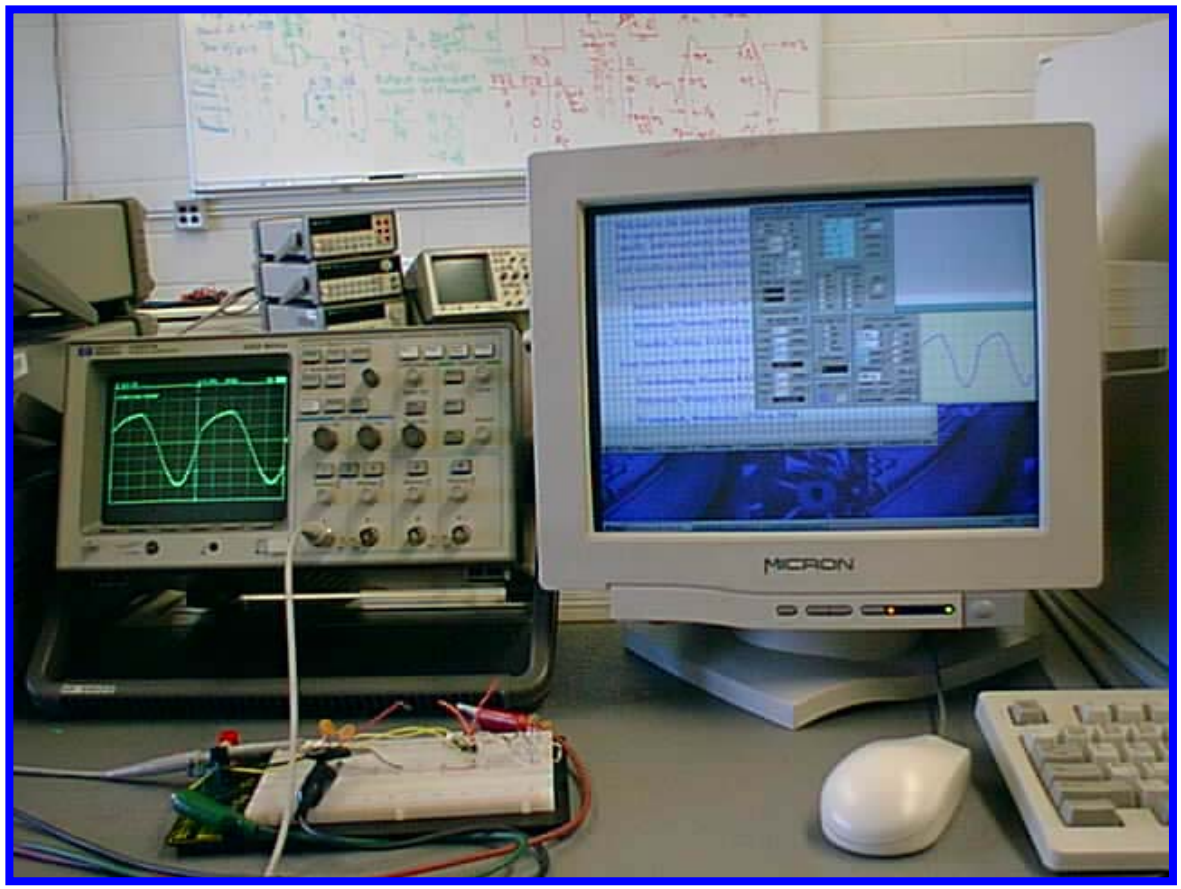
Interactive Internet Laboratory

- Interactive Web-based lab experiments.
- Web-based instrument controls.
- Subject tutorials.
- Computer controlled bench-top HP instruments consisting of a digital multi-meter, oscilloscope, signal generator and programmable power supply.
- A custom Web browser (WebLAB) that tightly integrates all of the above hardware and software.
- On-line experiments and support courseware may be seen and down loaded at: www.mission-technology.com

Interactive Internet Laboratory

HP Computer Controlled Instruments

Interactive Internet Laboratory



Lab Experiment with PC Control Panel

Interactive Experiment Page in Custom WebLAB Browser

Use the DVM for all measurements in this lab session. Keep one end of the DVM on ground, attach a wire to high lead of DVM and probe the different voltages by moving the wire around.

Wire up Fig A. And measure the voltage at RL.

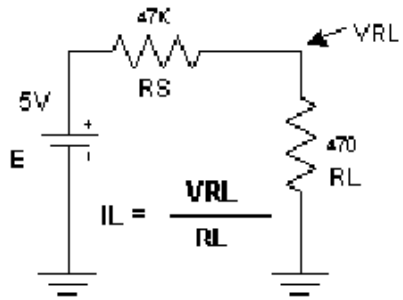


Fig. A

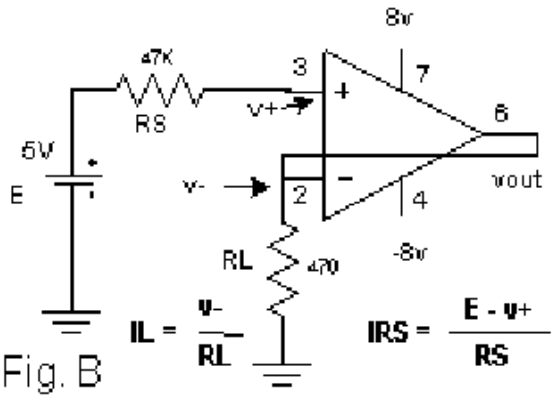


Fig. B

Wire up the circuit of Fig B. and measure the voltage at E, v+(pin3), v-(pin2), and vout(pin6)

1. The current through RL in Fig. A is [ ] ma.

2. The current through RS in Fig. A is [ ] ma.

3. The current through RL in Fig. B is [ ] ma.

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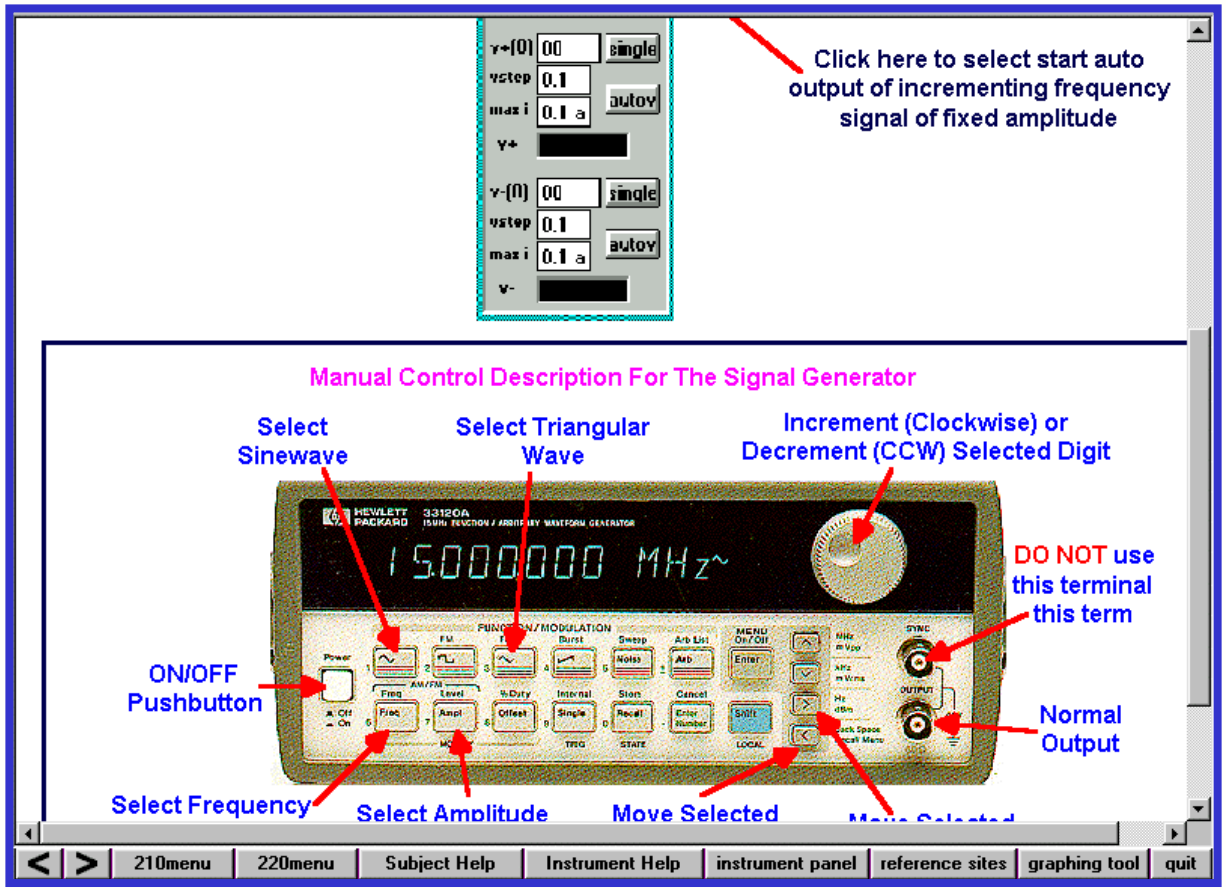
Instrument Tutorial in custom WebLAB browser



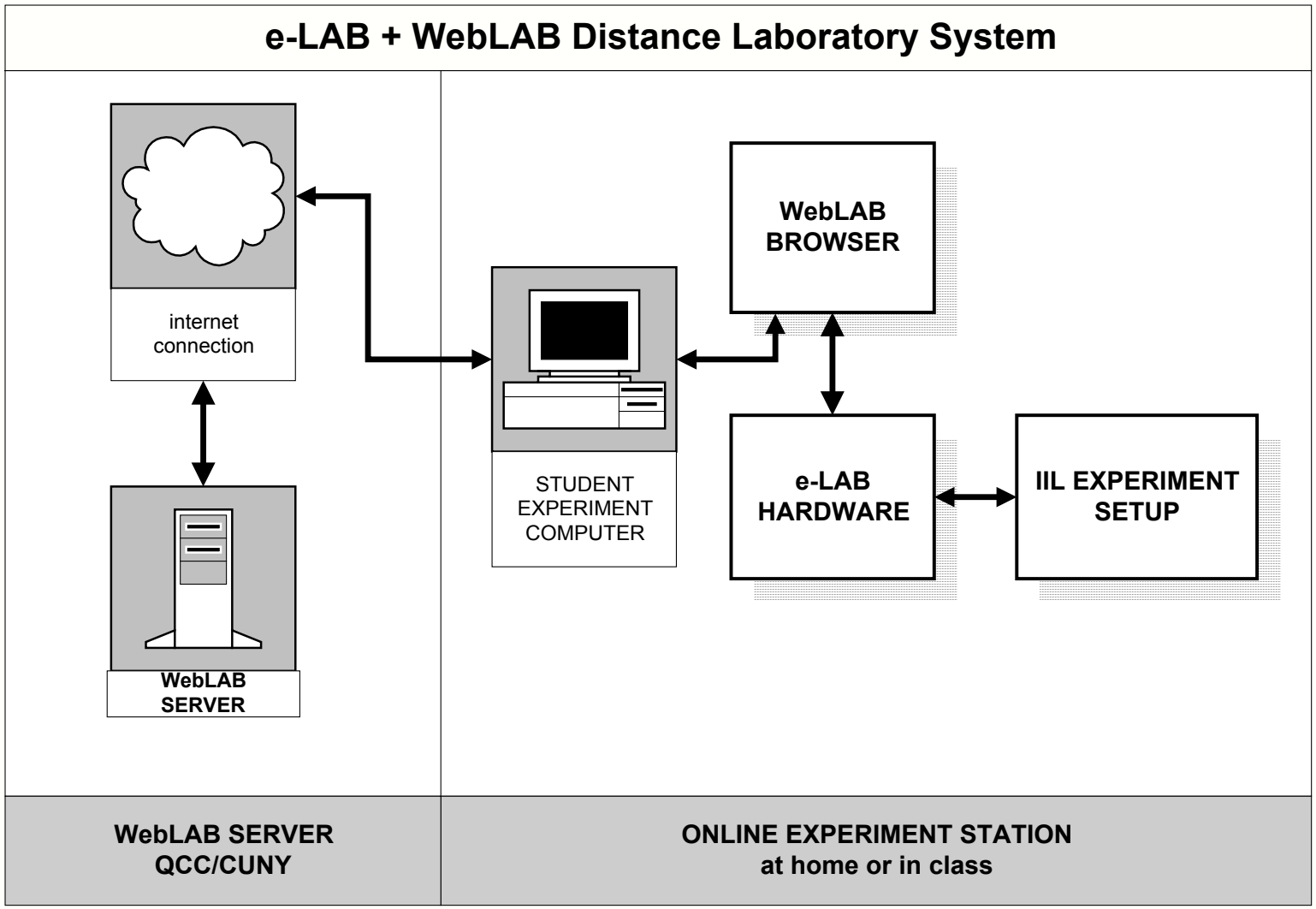
IIL Features

- Real laboratory instruments may be controlled through a PC by using an integrated computer control panel or manually.
- Students have on-line access to pertinent instrumentation and interactive subject tutorials.
- There is a Web page for each part of a multi-part experiment.
- Students must progress through each Web page to a subsequent Web page only by correctly answering verbal and computational questions.

Importance of Interactivity in IIL

In order to advance to the next part of an experiment, a student must, not only have assembled all experimental data, but must also have demonstrated comprehension and data correctness by answering key questions interactively on the Web page.

Distance Hands-on Laboratory



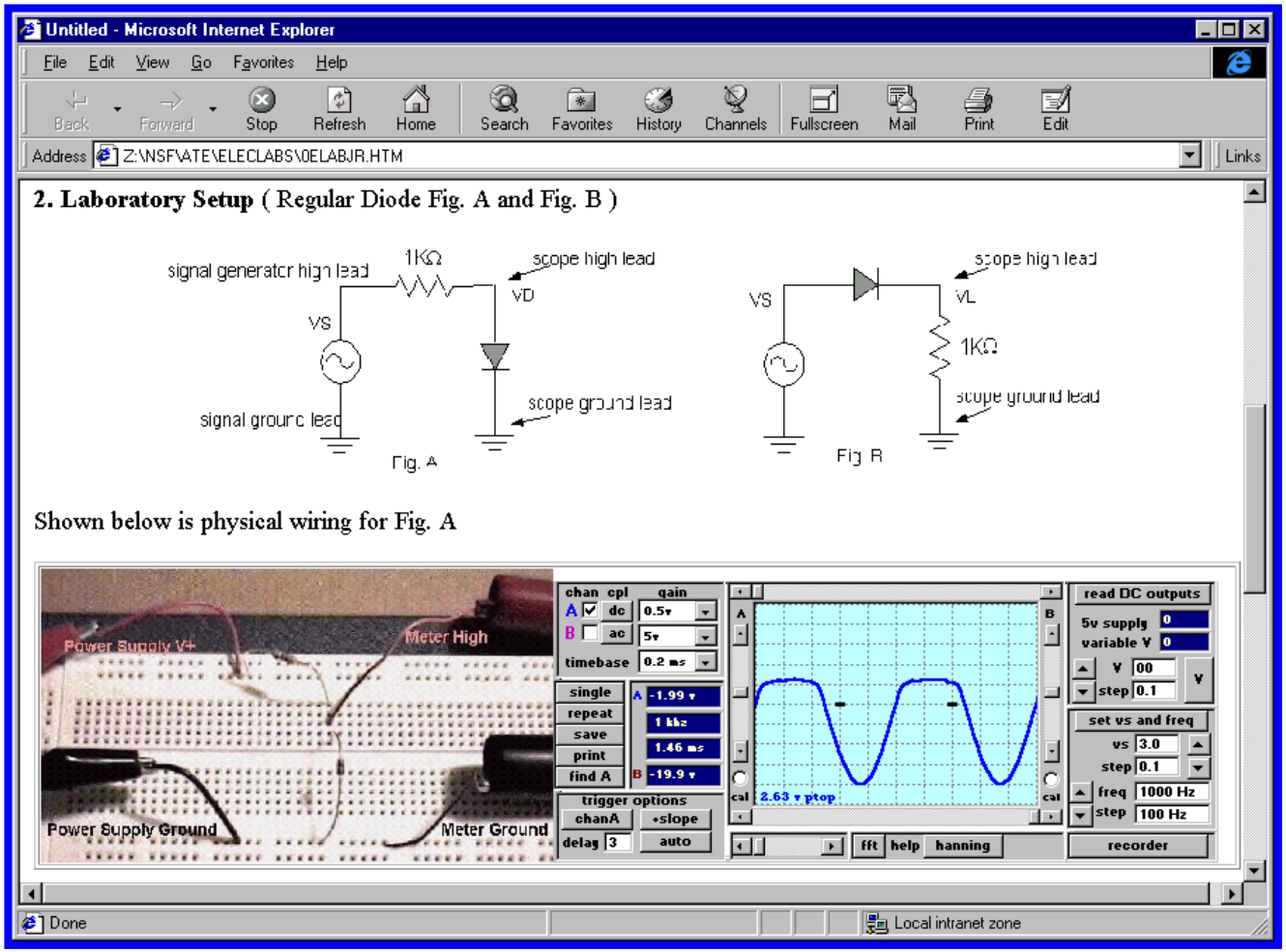
e-LAB Instrument Box

5” x 4.25” x 1.5”

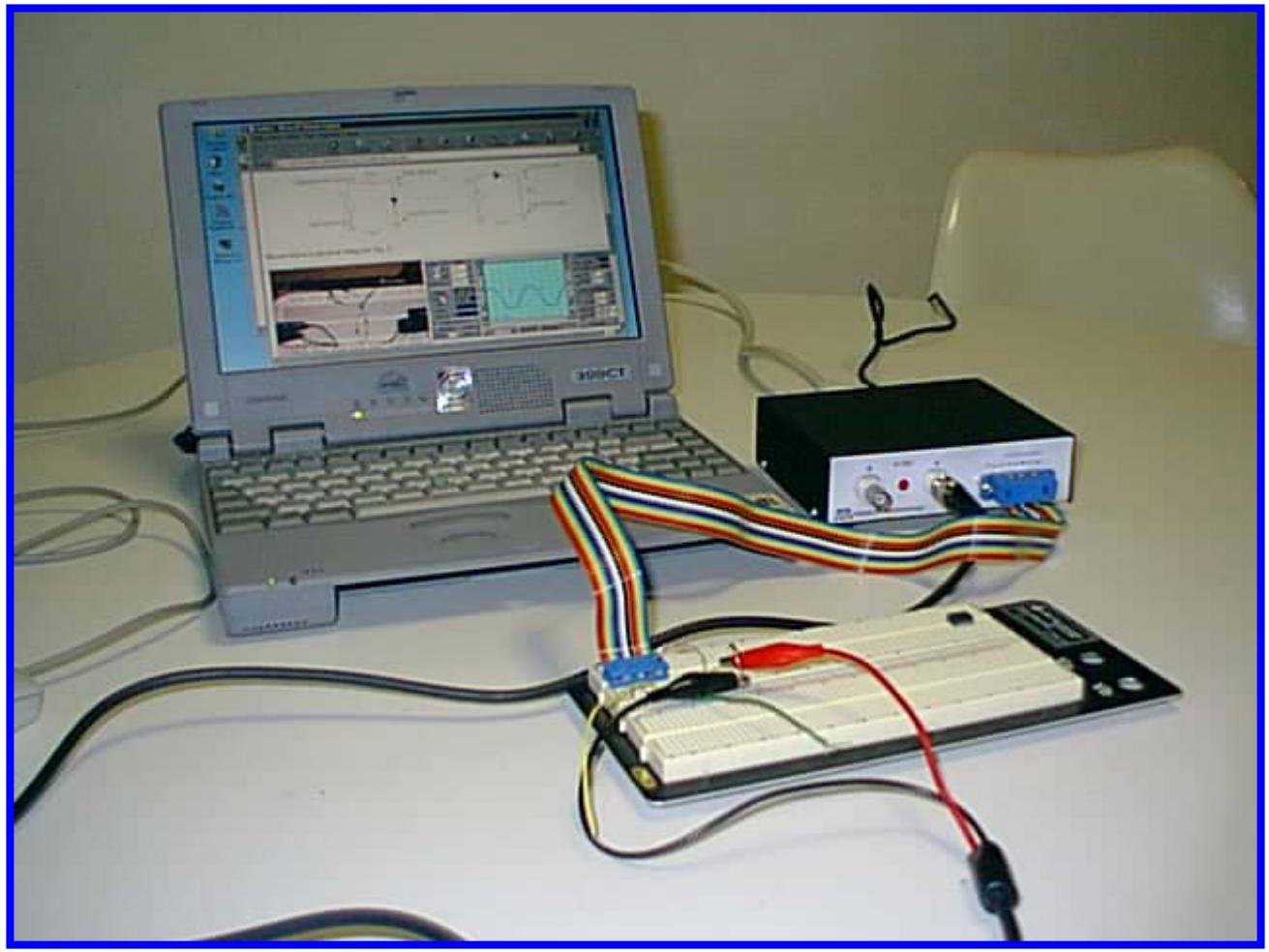
e-LAB Capabilities

- A dual channel oscilloscope
- Digital voltmeter
- Triple programmable power supply
- Sine square generator
- Spectrum analyzer
- Strip chart recorder
- Frequency counter

WebLAB Software



e-LAB in Action



First Trial

- This project was the next logical step to our online lab research initiative.
- We performed the trial with volunteers from a regular lab class comprised of students, not pre-selected in any way, whose average HS entrance grade hovers near C.
- Our cohort was typical for an urban community college where many are poorly prepared for college work, lack good study skills, and are poorly motivated.
- Of course, we do have some students who are well prepared and highly motivated.

Trial Questions

- Will students be able to successfully carry out all parts of a lab experiment at home using e-LAB and WebLAB?
- Will the e-LAB instrument hold up to months of unsupervised student use and rough knapsack transport?
- Can the e-LAB instrument carry out all the experiments designed for the Hewlett Packard suite of instruments as used in the IIL system.?
- What are the possible benefits from this approach for the student when compared to other methods?
- What other problems and drawbacks will be observed?

Trial Methodology

- The first two lab sessions were carried out in class with 19 students working in 6 squads
- All the students became familiar and comfortable with using the RIIL system.
- At the end of the third lab session, students who had computers and Internet access were given an e-LAB, with wires and components to work at home.
- Success was measured by the students' ability to submit competed lab reports with correctly captured signal waveform results and processed data before the start of the next regular session.

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Trial Methodology

- Those students who not successful working independently had an opportunity to do the lab with other students at the next lab session.
- Communications with the students were carried out mostly by email. Phone calls were used in one instance when email was not successful.
- Meetings during the week also took place whenever necessary to help solve problems.
- To insure that outside collaboration did not result in merely copying results, frequent quizzes, dealing with practical and theoretical aspects of the experiments, were given in class every 3 weeks.

Summary of Outcomes

- Out of three squads that originally tried the remote lab approach, 5 students or about one quarter emerged with the ability to do the labs successfully at home.
- Students with the instrument at home could progress faster than the weekly lab schedule.
- Two talented students decided to purchase their own breadboards and parts to experiment on their own.
- As a consequence of students working at home, the regular in-class size was reduced.
- This hybrid approach did require more instructional effort.

Trial Conclusions

- Students who were prepared and motivated did successfully carry out all the laboratory experiments.
- The e-LAB instrument survived three months of student use and transport for this project.
- Most experiments originally designed for HP set of instruments were carried out unmodified.
- Well-prepared students loved the trial because it saved them time and empowered them to carry out their own pet electronic projects in addition to the regular set of lab experiments.

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Trial Conclusions

- Most of the students, as anticipated, were unable to do their experiments at home since these students are not used to working on their own.
- Collaboration was impossible to extremely difficult for many because our college has no dorms and students must travel from many parts of New York City.
- More online capability and support as well as better and more rigorous earlier preparation are necessary.

A Low Cost Hands-On Laboratory Experience for Introductory Engineering Students

http://localhost/nsfrobot

www.mission-technology.com/nsfrobot

Future Impact on K-14

Major National Educational Issues

- Science and technology laboratory facilities are costly.
- There is a short supply of qualified science and technology teachers.
- School authorities are adopting and requiring performance standards.

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Future Impact on K-14

E-LAB + WebLAB Solutions

- A low cost solution for science and technology laboratory experimentation and demonstrations.
- Teacher education and training on instructional systems.
- Integration of science and technology performance standards into the design and implementation of experiments and demonstrations.

Sample High School Experiment

http://localhost/pendulum

www.mission-technology.com/pendulum

Contact

Nathan Chao: mission@sprintmail.com

Bernard E. Mohr: bemohr@tech-mohr.com